BSP-1200 - BENCH-SCALE ULTRASONIC LIQUID PROCESSOR

USER'S MANUAL

Notice of Liability:

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Patent Protection:

This ultrasonic equipment is manufactured under one or more of the following: US Patent 7,156,201, International Patent Application PCT/US2008/068697 and US Patent Application 13/648596.

Section 1

Introduction

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General User Information

Read This Manual First

Before operating your ultrasonic processor, read this User's Manual to become familiar with the equipment. This will ensure correct and safe operation. The manual is organized to allow you to learn how to safely operate this processor. The examples given are chosen for their simplicity to illustrate basic operation concepts.

Notes, Cautions and Warnings

Throughout this manual we use NOTES to provide information that is important for the successful application and understanding of the product.

In addition, we use special notices to make you aware of safety considerations. These are the CAUTION and WARNING blocks as shown here. They have important information that, if ignored, could have increasingly severe outcomes. These statements help you to identify and avoid hazards and recognize the consequences. One of three different symbols also accompany the CAUTION and WARNING blocks to indicate whether the notice pertains to a condition or practice, an electrical safety issue or an operator protection issue.

NOTE
Note statements provide additional information or highlight procedures.

CAUTION
Caution statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING
Warning statements point out conditions or practices that could result in personal injury or loss of life.

System Overview

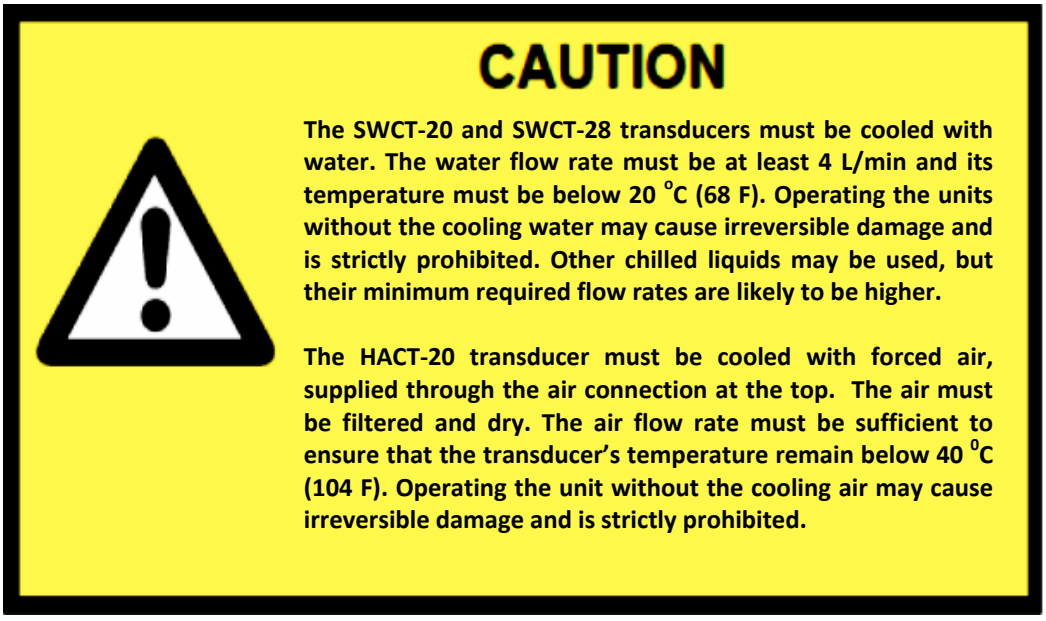
The BSP-1200 bench-scale ultrasonic liquid processor is designed for process optimization and medium-scale production. It outputs up to 1,200 W of acoustic power into the processed liquids and operates at the frequency of approximately 20 kHz. The processor is supplied with a 1,200 W ultrasonic generator, a piezoelectric transducer, a Barbell horn and an optional reactor chamber (flow cell).

Generator

The 1,200 W generator has rugged internal circuitry and ensures a continuous resonant frequency lock during operation. The LCD display can be used to change the settings for the ultrasonic amplitude, starting frequency and ramp-up or ramp-down parameters. Constant amplitude is provided, regardless of the power draw, which is automatically adjusted to compensate for variable loading conditions. The ultrasonic vibration amplitude level can be adjusted from 20 to 100 %. The generator passes strict CE test specifications for global applications.

Transducer

The BSP-1200 processor includes a sealed water-cooled piezoelectric transducer, SWCT-20 or SWCT-28. A hand-held air-cooled piezoelectric transducer, HACT-20, is also available upon request.


CAUTION
The SWCT-20 and SWCT-28 transducers must be cooled with water. The water flow rate must be at least 4 L/min and its temperature must be below 20 °C (68 F). Operating the units without the cooling water may cause irreversible damage and is strictly prohibited. Other chilled liquids may be used, but their minimum required flow rates are likely to be higher.
The HACT-20 transducer must be cooled with forced air, supplied through the air connection at the top. The air must be filtered and dry. The air flow rate must be sufficient to ensure that the transducer's temperature remain below 40 °C (104 F). Operating the unit without the cooling air may cause irreversible damage and is strictly prohibited.

Barbell Horn

Several types of Barbell horns may be utilized with the processor. The HBH or HBHO-type horns are commonly used in the flow-through processing mode, while the FBH-type horn is generally preferred for the batch processing mode. The horns have large output tip diameters (typically, 33 mm for HBH and HBHO, 35 mm for FBH) and can deliver extremely high vibration amplitudes - up to 100 microns at the atmospheric pressure. The amplitude is calibrated by a high-precision fotonic sensor. This level of vibration amplitude is unprecedented: all competing bench-scale ultrasonic systems with similar horn tip diameters are restricted to amplitudes below about 40 microns, which severely limits their utility. The ability to reach high amplitudes at the bench scale gives investigators a wide range of ultrasonic exposure conditions to optimize ultrasonic processes. When optimal conditions are established, the process can be transferred to commercial scale utilizing the ISP-3000 industrial ultrasonic processor.

Reactor Chamber (Flow Cell)

The BSP-1200 processor can be implemented in two processing modes: **batch** and **flow-through** (see below). With the use of the reactor chamber (flow cell), the processor can be configured for continuous liquid processing in the flow-through mode. When a large amount of material needs to be processed, this arrangement is preferable to the batch mode because it results in a much higher processing capacity, improved ultrasonic exposure uniformity and better temperature stability. During continuous ultrasonic processing, the use of the reactor chamber ensures that all working liquid is directed through the active cavitation zone(s) created by the incorporated Barbell horn (commonly, HBH or HBHO), resulting in homogeneous processing and high product quality. The reactor chamber supplied with the BSP-1200 processor includes a water-cooling jacket to help maintain the temperature of the working liquid at the desired level. Alternatively, a separate heat exchanger may be used.

System Productivity

Productivity rates provided by the BSP-1200 processor are highly dependent on the nature of each process and range from about 1 L/h for challenging tasks (e.g., top-down nanocrystallization of active pharmaceutical compounds) to over 1,000 L/h for fast processes (e.g., waste-water purification, biodiesel production).

Batch Mode

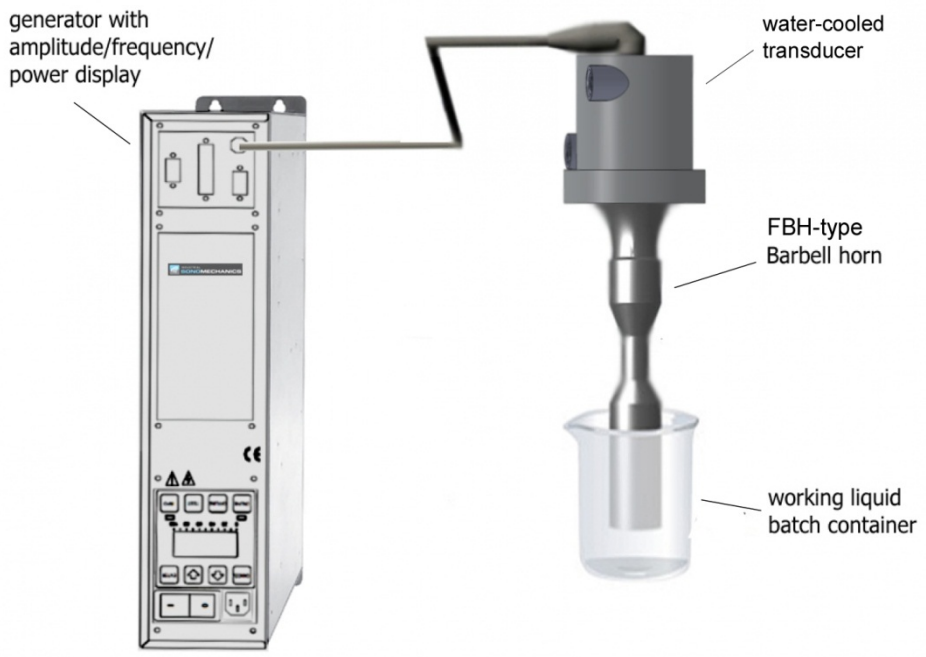


Figure 1 - 1. A schematic of the BSP-1200 ultrasonic processor in its FBH-type Barbell horn-based batch configuration is illustrated. The 1,200 W ultrasonic generator excites vibration in the piezoelectric transducer. The vibration amplitude is amplified to (up to) about 100 microns (maximum value, adjustable from 20 to 100 % at the generator) by the FBH-type Barbell horn, having the tip diameter of about 35 mm, and delivered to the liquid in the batch container. The horn is immersed into the liquid to slightly above its nodal point, where a groove or flange is located. Batch sizes of up to about 2 L can commonly be processed using this setup directly. Larger batches may require that the processed liquid be independently mixed. The liquid may be cooled by using a container with a cooling jacket.

Batch mode processing does not require the reactor chamber. In this mode, the processed liquid is placed in a batch container. Batch mode is commonly used for ultrasonic degassing of oils, paints, epoxies and other liquids as well as for new process investigations. Several configurations are possible, corresponding to different types of Barbell horns, which are inserted directly into the processed liquid.

Flow-Through Mode

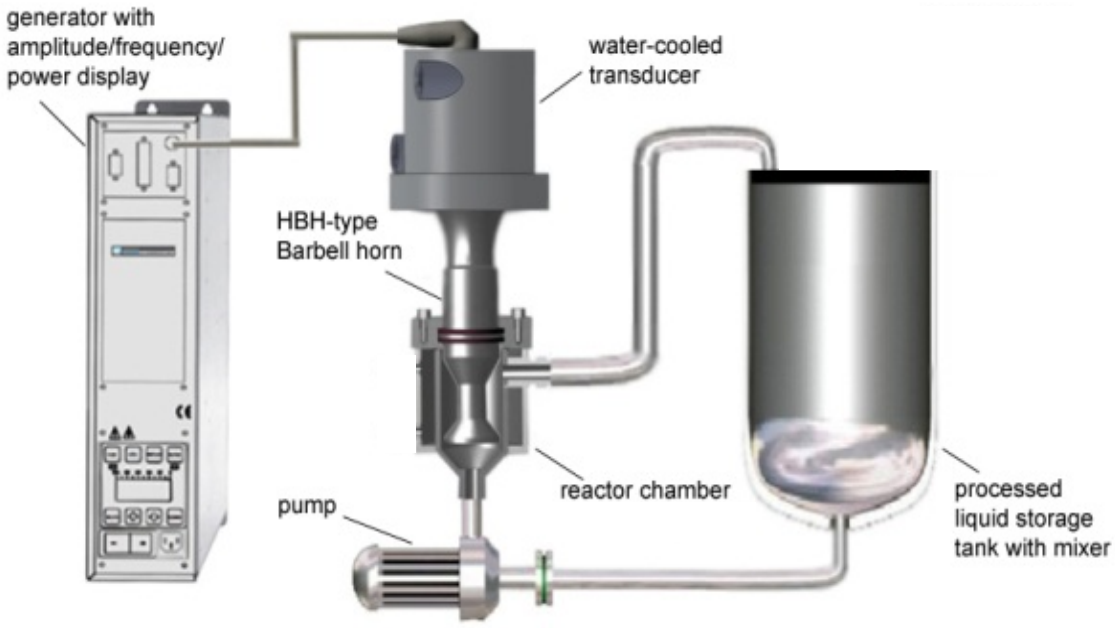


Figure 1 - 2. A schematic of the BSP-1200 ultrasonic processor in its most common recirculating configuration is illustrated. The 1,200 W ultrasonic generator excites vibration in the piezoelectric transducer. The vibration amplitude is then amplified to about 90 microns (maximum value, adjustable from 20 to 100 % at the generator) by the HBH or HBHO-type Barbell horn, having the tip diameter of about 33 mm, and delivered to the liquid, flowing through the reactor chamber. Other types of Barbell horns may be used as well.

Recirculating, single-pass and multi-reactor configurations are possible in the flow-through processing mode. In the recirculating configuration shown above, the material passes through the reactor chamber multiple times, which increases the cumulative exposure time. This configuration is recommended for challenging processes, such as nanocrystallization, nanoemulsification, deagglomeration, etc. The single-pass configuration is commonly used as a part of multistep processing involving different modalities. In this configuration, the working liquid coming from a previous processing step passes through the reactor chamber, after which it is either collected as the final product or continues down the line for further processing. This arrangement is common for faster processes, such as waste-water purification or biodiesel production. The multi-reactor configuration requires several BSP-1200 units to be used simultaneously and combines the advantages of the configurations described above.

Section 2

Health and Safety

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General Considerations

Please observe these health and safety recommendations for safe, efficient, and injury-free operation of your equipment. A typical system consists of the generator, remote button switch, connecting and grounding cables, transducer, Barbell horn and reactor chamber.

- **Proper Installation** - Operate system components only after they are properly installed and checked.
- **No Unauthorized Modifications** - Do not modify your system in any way unless authorized to do so by the manufacturer. Unauthorized modifications may cause injury to the operator and/or equipment damage. In addition, unauthorized modifications will void the equipment warranty.
- **Keep the Cover On** - Do not remove any equipment cover unless specifically directed to do so by the manufacturer. The generator produces hazardous electrical voltages which could cause injury.
- **Grounded Electrical Power** - Operate this equipment only with a properly grounded electrical connection. (See *Electrical Safety*, and the grounding instructions below.)
- **Comply with Regulations** - You may be required to add accessories to bring the system into compliance with applicable OSHA regulations for machine guarding and noise exposure.

IMPORTANT

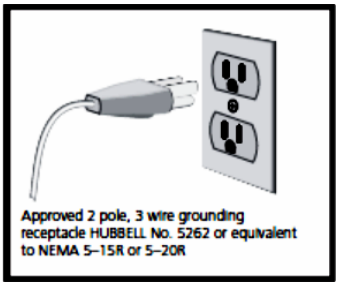
Never operate the generator with the cover off. This is an unsafe practice and may cause injury.

CAUTION

Parts sometimes vibrate at audible frequencies. Wear ear protection to reduce annoying or uncomfortable sounds. In addition, sound absorbing materials, enclosures or sound deflectors may be installed to reduce the noise level.

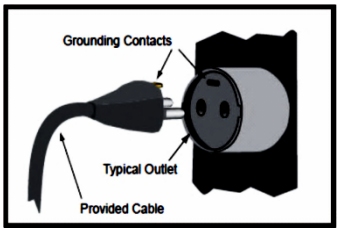
Electrical Safety

Domestic and International Power Grounding



For safety, this product has a three-wire, grounding-type power cord. Figure 2 - 1 illustrates the appropriate electrical outlet to use with the power cord that is included with 120 V rated generators shipped to North America.

Figure 2 - 1. Example of 120 Volt, Grounded, 3-Prong Receptacle



The power cable normally provided for international use is compatible with the power outlet used in many Continental European countries (Refer to Figure 2 - 2.)

Figure 2 - 2. International 220/240V Grounding

CAUTION

If you have a two-prong electrical receptacle, we strongly recommend that you replace it with a properly grounded three-prong type. Have a qualified electrician replace it following the National Electric Code and any local codes and ordinances that apply.

CAUTION

If there is any question about the grounding of your receptacle, have it checked by a qualified electrician. Do not cut off the power cord grounding prong, or alter the plug in any way. If an extension cord is needed, use a three-wire cord that is in good condition. The cord should have an adequate power rating to do the job safely. It must be plugged into a grounded receptacle. Do not use a two-wire extension cord with this product.

SECTION 3

Generator Installation

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CONNECTING SYSTEM CABLES – HACT-20 TRANSDUCER **13**

Key Generator Features

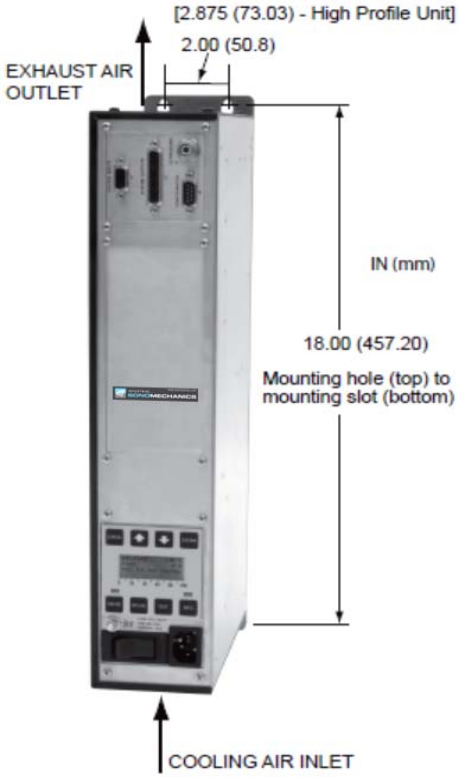
- **Compact Enclosure Size** means that a very small footprint is required. 220/240VAC systems - come in a low profile (3.5”) compact enclosure. 110/120VAC systems - come in a high profile (5.25”) enclosure.
- **Pulse Width Modulation** incorporates circuitry giving the generator the ability to efficiently change the output amplitude.
- **Linear Ramp Soft-Start** circuitry allows the transducer/horn to be brought to operating amplitude smoothly, minimizing start-up surges and abnormal stress to the transducer, horn and generator.
- **Automatic Tuning** tracks the resonant frequency of the acoustic stack (transducer/horn assembly) and adjusts the generator output frequency to match it. This eliminates the need to manually tune the generator.
- **Line Voltage Regulation** automatically maintains constant amplitude regardless of line voltage deviation. The available output power is maintained with any voltage input within the specified range. This provides consistent system performance regardless of line voltage fluctuations. It also eliminates the need for bulky, external constant-voltage transformers.
- **Load Regulation** provides constant ultrasound amplitude automatically regardless of power draw. The ultrasonic output amplitude level is held to within ±1%.
- **High Line-Voltage Power Supply** means that 220/240VAC systems will operate worldwide at the local high line voltage level, whether it is 200VAC @ 60Hz in Japan, 240VAC @ 50Hz in Europe or 208VAC @ 60Hz in the United States. There are no internal transformer taps to change for world-wide operation.
- **Flow-Through Cooling Tunnel** with a high-performance heat-sink and thermostatically controlled fan reduces thermal gradients and increases component life.
- **AC Power Inrush** protection reduces electrical stress on the internal components by protecting them from AC power start-up transient current surges.
- **Multiple Electronic Overload** protection circuits prevent instantaneous component failure in the event of extreme output overload conditions.
- **CE Certification** means that the system meets the required European standards to be sold and used in Europe.

Unpacking

Carefully open your shipping container, and make sure it contains the items shown on the shipping documents. Inspect all items, and report any damage immediately.

Placing

Vertical Panel Mount Chassis



Make certain the generator placement and cable routing allows for easy access and that they do not interfere with normal operation. The operator should have unobstructed access to any control switches and should have a clear view of the LCD panel, and generator status LEDs.

Hang the generator securely by the upper and lower holes in the mounting panel with its control panel easily accessible as shown in Figure 3-1. Allow at least 5 inches (13 cm) of space on the top and bottom of the generator chassis for air circulation. If the generator is installed inside an enclosure with a front door, be sure to allow at least 3 inches (8 cm) clearance behind the door for the system cables.

CAUTION

Allow 5 inches for air ventilation at the cooling air inlet and at the exhaust air outlet. The fan draws in fresh air to cool the internal components, reduce thermal gradients and increase component life.

Figure 3 - 1. Vertical Panel Mount Chassis Placement (Low profile unit shown with optional panel mounting plate.)

Horizontal Panel Mount Chassis

Generator placement and cable routing should permit easy access and not interfere with normal system operation. Allow at least 5 inches (13 cm) of space on both ends of the generator chassis for air circulation. Allow a 3 inch space (8 cm) in the front of the chassis for cable clearance.

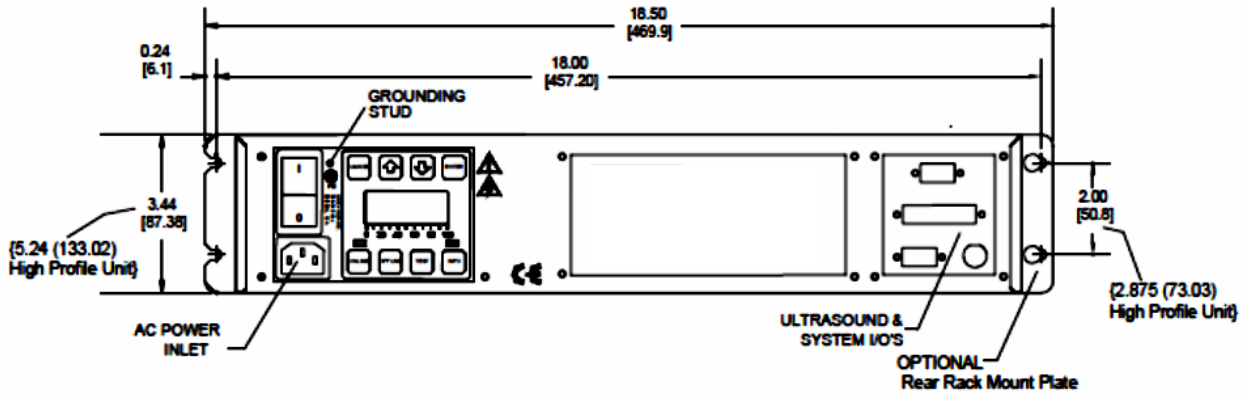
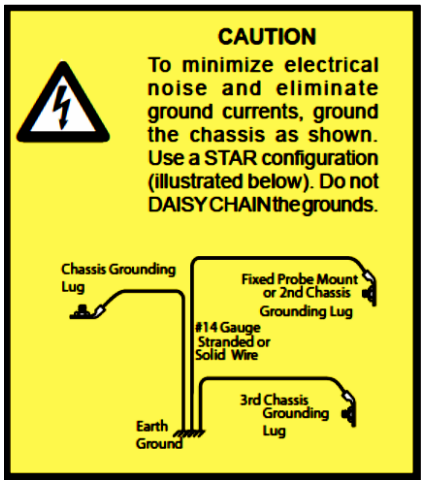


Figure 3 - 2. Horizontal Panel Mount Chassis (low profile unit shown with optional rear rack mount plate)

RFI Grounding

In addition to the safety considerations previously mentioned, proper grounding at the generator power cord is essential for the effective suppression of electrical noise or RFI (Radio Frequency Interference). Every ultrasonic generator contains a RFI filter which blocks noise on the AC power line from entering the system control circuitry. This filter also prevents ultrasonic frequency noise from being fed back into the AC power line. In order for the RFI filter to operate properly, it is necessary to correctly ground the system. Run a grounding wire from the ground stud connection (see Figure 3 - 2) to the nearest grounded metal pipe or equivalent earth ground, and secure it with a ground clamp.


CAUTION
To minimize electrical noise and eliminate ground currents, ground the chassis as shown. Use a STAR configuration (illustrated below). Do not DAISY CHAIN the grounds.
Chassis Grounding Lug
Fixed Probe Mount or 2nd Chassis Grounding Lug
#14 Gauge Stranded or Solid Wire
3rd Chassis Grounding Lug
Earth Ground

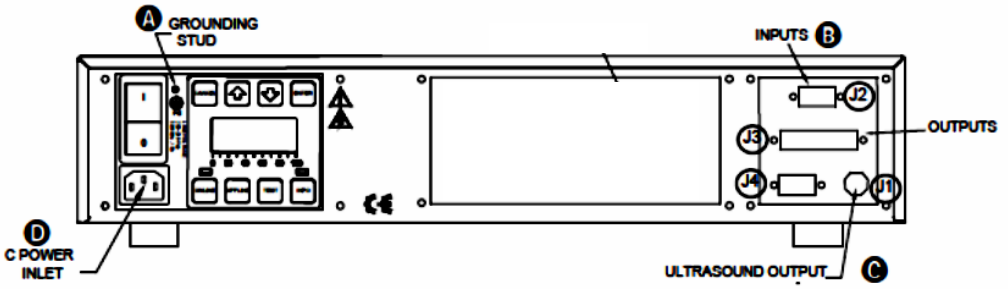
Connecting Cables (Quick Start Guide)

The connections are the same for both the vertical and horizontal generator configurations. However, the panel location of the connectors differs between the two chassis styles. Details about the various system connectors are covered in Section 4.

Power Cords

The 3 - wire grounding AC line cords supplied with the standard generators are matched to the ultrasonic output power rating and the continent of specified use.

Figure 3 - 3. Horizontal Bench Generator



NOTE
Horizontal bench generator is shown for reference. Vertically mounted units use the same connections, but those connections have a different orientation. (See Figure 4-1.)

Connecting System Cables –SWCT-20 and SWCT-28 Transducers

(See Figure 3 - 3 for connection locations.)

Step 1. Ground the generator chassis using the supplied 14 - Gauge wire - attaching it to the grounding stud.
A in Figure 3 - 3.

Step 2. Attach the included cable with remote button switch to the generator's input HD - 15 connector, J2 on the I/O panel.
B in Figure 3 - 3.

Step 3. Attach the high voltage coax cable from the transducer to the ultrasound output connector J1.
C in Figure 3 - 3.

Step 4. Power cords with an IEC connector are always supplied with bench chassis style and 240 V rated generators. Connect the AC power cord to the generator IEC power inlet connector, and plug the other end into an approved AC outlet. 120 V rated systems have permanently mounted power cords.
D in Figure 3 - 3.

Connecting System Cables – HACT-20 Transducer

(See Figure 3 - 3 for connection locations.)

Step 1. Ground the generator chassis using the supplied 14 - Gauge wire - attaching it to the grounding stud.
A in Figure 3 - 3.

Step 2. Attach the handheld transducer's HD-15 system input connector to the generator's input HD - 15 connector, J2 on the I/O panel.
B in Figure 3 - 3.

Step 3. Attach the high voltage coax cable from the transducer to the ultrasound output connector J1.
C in Figure 3 - 3.

Step 4. Power cords with an IEC connector are always supplied with bench chassis style and 240 V rated generators. Connect the AC power cord to the generator IEC power inlet connector, and plug the other end into an approved AC outlet. 120 V rated systems have permanently mounted power cords.
D in Figure 3 - 3.

SECTION 4

Generator Connections

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AC POWER INLET PANEL **16**

IEC AC POWER INLET CONNECTOR 16
POWER SWITCH/CIRCUIT BREAKER 16
CHASSIS GROUND STUD 16
ULTRASOUND OUTPUT CONNECTOR 16

Panel Layout Overview

Vertical Panel Mount Chassis

This section provides an overview of the vertical panel mount chassis panel layout, which includes panel areas dedicated to various standard system functions and options. Figure 4 - 1 illustrates the panel layout for a vertical panel mount chassis.

AC Power Inlet Panel

- **A** IEC Power Inlet Connector – Attaches to an IEC style power cord. 120 V rated systems have permanently mounted power cords.
- **B** Power Switch / Circuit Breaker – Used to switch system power **ON** and **OFF**.
- **C** Chassis Ground Stud – Chassis connection for a protective earth ground.

System Status Control Panel and Display

- **D** **INFO** Key.
- **E** System Operating Mode Keys and Status LEDs.
- **F** Power Output Level Scale.
- **G** 4 - line LCD Display.
- **H** Display Control Keys.
  Section 5 provides descriptions of these basic user controls and status LEDs.
- **J** Blank Panel.

System I/O Panel

- **K** System Input Connector – Connections for system control input signals
- **L** System Output Connector – Connections for system status output signals
- **M** Ultrasound Output Connector – Coaxial high voltage connection to ultrasonic transducer
- **N** Configuration Port Connector – Digital control port to modify system parameters

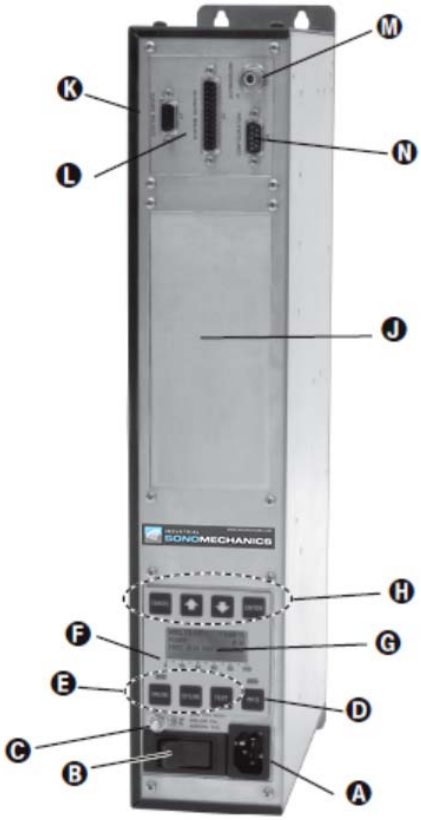

Figure 4 – 1. Panel Layout - Vertical Panel Mount Generator

AC Power Inlet Panel

The standard AC power inlet panel is described in this section.

IEC AC Power Inlet Connector

The IEC AC power inlet connector mounted on the system AC power inlet panel requires a properly configured IEC compliant power cord, which enables worldwide system operation by simply changing the power cord.

Low profile systems are equipped with a 10 Amp rated IEC inlet connector. The high profile systems include a 16/20 ampere rated IEC inlet connector.

An appropriately rated power cord must be securely attached to the system's IEC inlet connector. If the correct power cord configuration is not included with the system for the local AC power outlet at your location, an appropriate IEC power cord should be available from a local electrical parts supplier.

Power Switch/Circuit Breaker

The power switch/circuit breaker has a rocker type actuator switch that will activate or deactivate the AC power to the system. The power **ON** position is marked with the internationally recognized **I** symbol, the power **OFF** position is marked with the **0** symbol. This power switch also integrates an appropriately sized over-current protection circuit breaker function in the generator.

If an over-current condition trips the circuit breaker, it will automatically switch to the **OFF** position. If the overload current that caused the circuit breaker to trip is due to a transient condition, the circuit breaker can be reset by switching the actuator back to the **ON** position. If when resetting the circuit breaker after it has tripped, it immediately trips again, there is likely an internal system malfunction, and the generator will require service.

Do not repeatedly try to reset the circuit breaker. If it trips, this will only cause more damage to the generator.

Chassis Ground Stud

The chassis ground stud is used to attach a protective earth ground to the generator. This will aid in the suppression of electrical interference or radio frequency interference (RFI) that is common in an industrial environment. The chassis ground stud is **C** in Figure 4 - 1. Proper system grounding is discussed in Section 3.

Ultrasound Output Connector

The ultrasound output connector used with all standard generators is a high voltage (5000V) coaxial style SHV-BNC connector. This connector provides superior shielding of electrical noise, compared to other types of connectors. The ultrasound output connector mates with a fully shielded coaxial ultrasound cable that is secured with a simple and reliable quarter-turn bayonet style attachment mechanism.

Figure 4 – 2. Ultrasound Output Connector

CAUTION

The ultrasonic output from this connector (that drives the attached ultrasonic load) is a very high AC voltage. At high power levels this can exceed 2 amperes of current and must be securely terminated via the ultrasound cable for safe operation. Use original equipment ultrasound cables for safe and reliable system operation. Improperly assembled ultrasound cables can result in high voltage arcing and will destroy the ultrasound connectors.

Do not use your generator if there is any evidence of arcing (black carbon deposits) on either the ultrasound output connector or the ultrasound cable connectors.

SECTION 5

Generator Status and Controls

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Control Panel and Display Overview

This section provides an overview of the control panel and display. The panel has two functions:
1) monitoring, using the LED status lights, and
2) display and control, using the Display Controls with the LCD display.
Figure 5 - 1 identifies the primary parts of the panel that are described in the pages that follow.

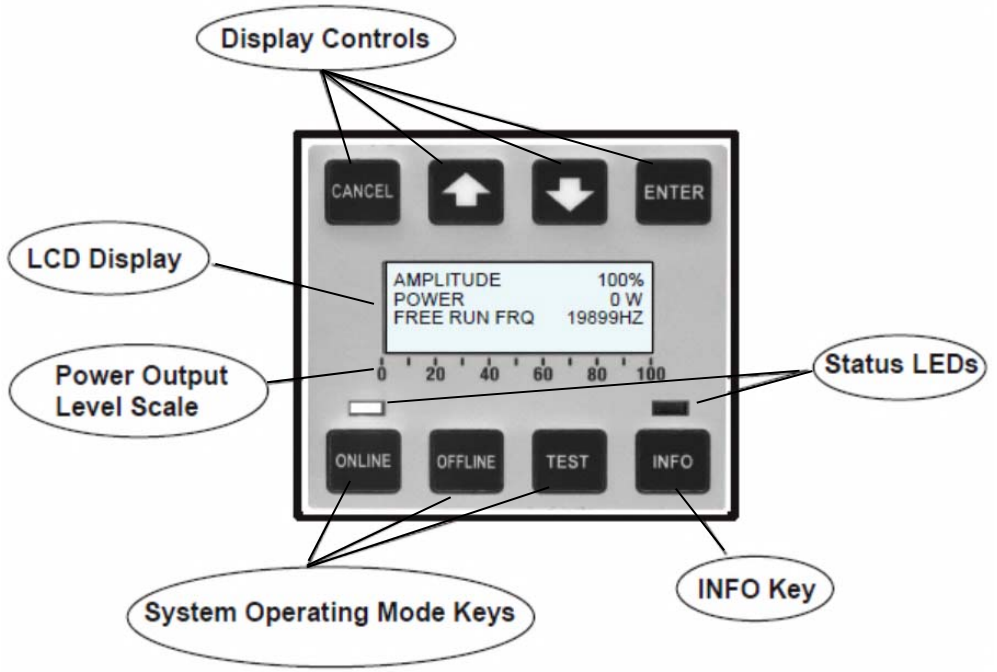

Figure 5 – 1. Control Panel and Display

Display Controls

The four keys on the top of the panel provide control for the LCD display.

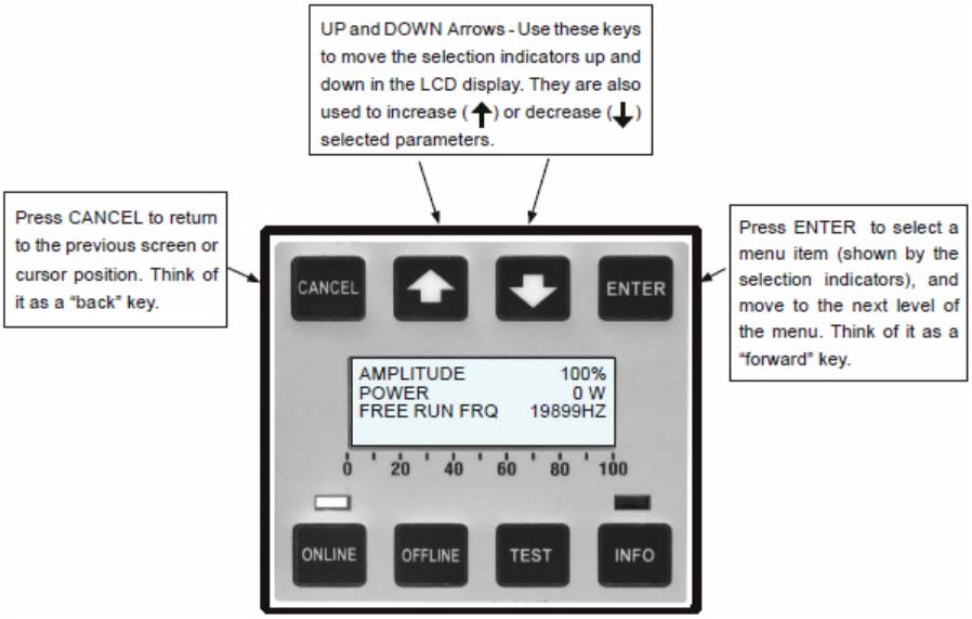
UP and DOWN Arrows - Use these keys to move the selection indicators up and down in the LCD display. They are also used to increase (↑) or decrease (↓) selected parameters.
Press CANCEL to return to the previous screen or cursor position. Think of it as a "back" key.
Press ENTER to select a menu item (shown by the selection indicators), and move to the next level of the menu. Think of it as a "forward" key.
CANCEL
ENTER
AMPLITUDE 100%
POWER 0 W
FREE RUN FRQ 19899HZ
0 20 40 60 80 100
ONLINE
OFFLINE
TEST
INFO

Figure 5 – 2. Control Panel Display Controls

LCD Display

The 4-line LCD display gives the operator a basic interface for generator monitoring and control. Figure 5 - 3 illustrates a typical view of the display just after the generator has been powered up.

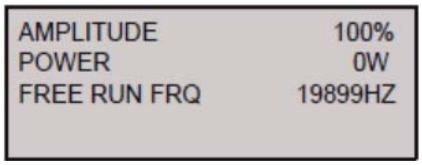

Figure 5 – 3. Display After Power-up

Power Output Level Scale

Figure 5 - 4 shows what a display might show when the TEST key is pressed. In this example, the generator is producing an ultrasound signal at approximately 90% of its capacity.

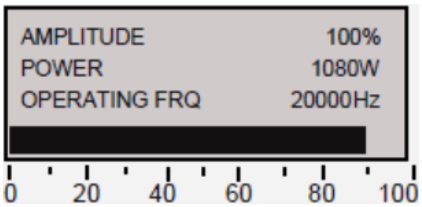

Figure 5 – 4. Power Output Level Scale

System Operating Mode Keys

The system operates in three basic modes: **ONLINE**, **OFFLINE**, and **TEST**.

Figure 5 - 5 shows the mode keys at the bottom of the control/display panel. Also note the location of the left and right status LEDs.

ONLINE

Press the **ONLINE** key to operate in the online mode.

In this mode, ultrasound can be activated. The LED above the **ONLINE** key is GREEN when the generator is online.

OFFLINE

Press the **OFFLINE** key to operate in the offline mode. Select this mode during your process setup without ultrasound activated.

In the offline mode, ultrasound cannot be activated. The LED above the **ONLINE** key is YELLOW when the generator is offline.

TEST

Press the **TEST** key to operate in the test mode.

In this mode, ultrasound output will activate for the time that the **TEST** key is pressed. In test mode, the right status LED changes from being GRAY (Off) to GREEN. This mode is typically used when setting up an application. It is not normally used during an actual process.

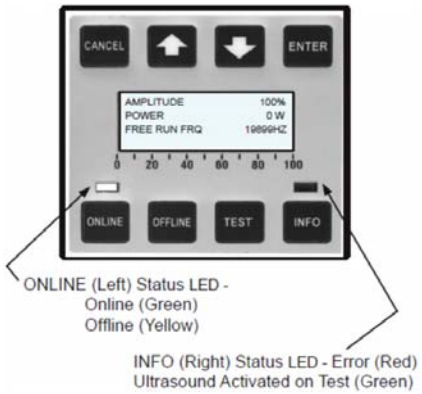

Figure 5 – 5. Operating Mode Keys and LEDs

NOTE

Use the test mode only when:
1) The ONLINE GREEN LED indicates that the generator is online, and
2) When the ultrasound output cable at J1 is connected to a probe/stack.

INFO Key

Press the **INFO** key.

Figure 5 - 6 shows what the **INFO** display looks like.

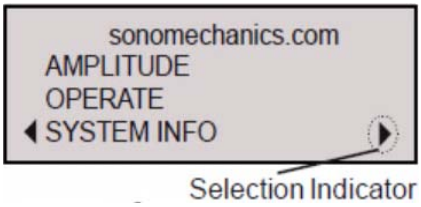

Figure 5 – 6. INFO Display

SYSTEM INFO

Select **SYSTEM INFO** (See the selection indicators shown in Figure 5 - 6), and press **ENTER** to view:

- Firmware revision, and
- System identification including model number

See Figure 5 - 7 for a **SYSTEM INFO** example.

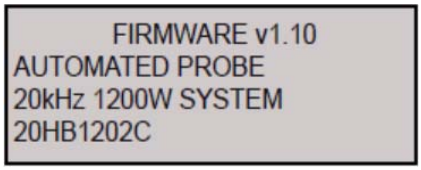

Figure 5 – 7. SYSTEM INFO Example Display

OPERATE

Select **OPERATE**, and press **ENTER** to view:

- Amplitude,
- Power, and
- Free Run Frequency

These values reflect what the parameters were during previous operation.

See Figure 5 - 8 for an example of the **OPERATE** display.

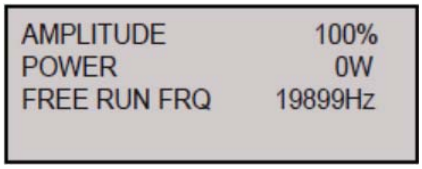

Figure 5 – 8. OPERATE Example Display

AMPLITUDE

Select **AMPLITUDE**, and press **ENTER** to view, and to change the amplitude setting.

Amplitude is a value with a minimum of 20% and a maximum of 100%.

See Figure 5 - 9 for an example of the **AMPLITUDE** display.

Use the **UP** and **DOWN** arrow keys to set the desired value.

Make the change, press **ENTER**, and **ENTRY ACCEPTED** will be displayed confirming that the change was made.

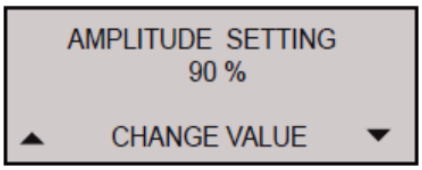

Figure 5 - 9. AMPLITUDE Example Display

NOTE

Pressing the UP arrow key when 100% is displayed will change the percentage to 20%.
Pressing the DOWN arrow key when 20% is displayed changes the percentage to 100%.

Status LEDs

Status LEDs provide operating status for system power, the system operating mode and system output status as described below:

INFO Status Indicator

(*On the panel's right side*)

GREEN = Generator ultrasound output is activated.

RED = Could be due to one of the three conditions listed below:

Red Fast Flashing (4 flashes per second) - Indicates an under or over voltage condition in the AC line voltage connected to the generator. If the proper voltage range is not maintained, a line voltage fault will inhibit system operation, and the **INFO** status indicator will flash approximately four times per second. This flashing may occur momentarily when the system power is switched off and does not indicate a problem or malfunction.

RED Slow Flashing (1 flash per second) - Indicates that the DC bus capacitors are not charged to the proper voltage level. This is a normal condition whenever the system is switched on. The DC bus capacitors will normally charge to the proper voltage level within 10 seconds. Then the **ONLINE** indicator should switch to a steady GREEN (if **ONLINE**), or YELLOW (if **OFFLINE**). If the slow flashing indication continues and does not stop, an internal problem is preventing the DC bus capacitors to charge to the proper voltage level. The system will require service, if this fault condition continues to flash and does not stop. Do not allow the system to operate in this fault condition for an extended period of time. There is likely a shorted internal component causing this type of fault condition, and some internal parts might get very hot as a result. If this fault occurs, switch the unit off, and return the generator for service.

Steady RED (No flashing) - Indicates that there is a problem with one of the DC voltage outputs on the system control power supply. If this fault condition occurs, switch off the system power, and return the generator for service.

ONLINE Status Indicator

(*On the panel's left side*)

GREEN = ONLINE

Generator ultrasound output is activated.

YELLOW = OFFLINE

Generator ultrasound output is deactivated.

Some system fault conditions will reset automatically. A system overload inhibits the ultrasound output when it occurs, but will automatically reset when the next ultrasound activation signal begins.

If an overtemperature condition is the cause of the fault indication, the fault condition will automatically reset when the system cools. Most other system fault conditions will not reset. In those cases the generator needs servicing.

SECTION 6

System Assembly, Testing and Operation

ULTRASONIC TRANSDUCER **23**

SEALED WATER-COOLED TRANSDUCERS, SWCT-20 AND SWCT-28 23
Coolant Inlet & Outlet 23
Support Rod 23
Ultrasound Input Connector (SWCT-20) 23
Ultrasound Input Connector (SWCT-28) 23
HAND-HELD AIR-COOLED TRANSDUCER, HACT-20 24
Air Fitting 24

ULTRASONIC HORN **25**

ATTACHING THE MOUNTING STUD TO THE HORN **25**

ATTACHING THE HORN TO THE TRANSDUCER **25**

DETACHING THE HORN FROM THE TRANSDUCER **26**

REMOVING THE MOUNTING STUD FROM THE HORN **26**

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RUNNING/STOPPING THE SYSTEM **27**

RUNNING THE SYSTEM 27
STOPPING THE SYSTEM 27

REACTOR CHAMBER **28**

ASSEMBLING THE REACTOR CHAMBER WITH A BARBELL HORN **29**

Ultrasonic Transducer

Ultrasonic transducers are devices used to convert electric energy coming from an ultrasonic generator into mechanical energy in the form of ultrasonic vibrations. Two types of piezoelectric transducers can be used with the BSP-1200 ultrasonic processor: sealed, water-cooled (SWCT-20 and SWCT-28) or hand-held, air-cooled (HACT-20).

Sealed Water-Cooled Transducers, SWCT-20 and SWCT-28

Sealed water-cooled transducers, SWCT-20 (see Figure 6 - 1) and SWCT-28 can operate continuously (24/7), generating vibration amplitudes up to 20 microns (SWCT-20) or 28 microns (SWCT-28) at the frequencies around 20 kHz. They are compatible with all ISM's ultrasonic horns. Sealed water-cooled transducers may be used in any liquid processing application of high-intensity ultrasound. They are completely sealed to the outside environment, which makes them immune to high-humidity conditions and suitable for processing flammable materials, such as fuels and organic solvents. SWCT-20 is preferred for flow-through operation where some back pressure in the processed liquid may be present, while SWCT-28 is optimal for batch-mode operation where there is no back pressure.

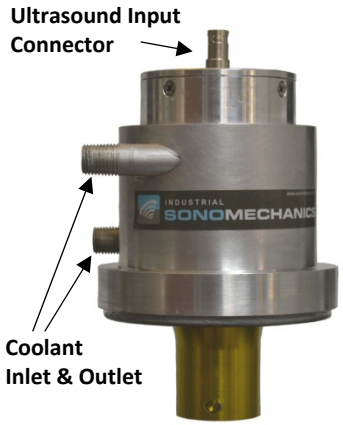

Figure 6 - 1. Sealed Water-Cooled Piezoelectric Transducer, SWCT-20

Coolant Inlet & Outlet

In continuous duty operation, it is important to keep the transducer cool with flowing water, supplied through the coolant inlet and taken out of coolant outlet. The water flow rate must be at least 4 L/min and its temperature must be below 20 ^{o}C. Other chilled liquids may be used, but their minimum required flow rates are likely to be higher.

CAUTION

Operating SWCT-20 and SWCT-28 without a cooling liquid may cause irreversible damage and is strictly prohibited.

Support Rod

The support rod (not visible in Figure 6 - 1) is screwed into the transducer chassis and is used for positioning the transducer in a clamp holder on a support stand.

Ultrasound Input Connector (SWCT-20)

The ultrasound input connector is a high voltage (5000V) coaxial style SHV-BNC connector. This connector provides superior shielding of electrical noise. The ultrasound input connector mates with a fully shielded coaxial ultrasound cable that is secured with a simple and reliable quarter-turn bayonet style attachment mechanism.

Ultrasound Input Connector (SWCT-28)

The ultrasound input connector is a high voltage (2000V) coaxial style N-type connector. This connector provides superior shielding of electrical noise and is sealed to the outside environment. The ultrasound input connector mates with a fully shielded coaxial ultrasound cable that is secured with a reliable threaded attachment mechanism.

CAUTION

The ultrasonic input through this connector (that drives the attached ultrasonic load) is a very high AC voltage. At high power levels this can exceed 2 amperes of current and must be securely terminated via the ultrasound cable for safe operation. Use original equipment ultrasound cables for safe and reliable system operation. Improperly assembled ultrasound cables can result in high voltage arcing and will destroy the ultrasound connectors.

Do not use your transducer if there is any evidence of arcing (black carbon deposits) on either the ultrasound output connector or the ultrasound cable connectors.

Hand-Held Air-Cooled Transducer, HACT-20

HACT-20 (see Figure 6 - 2) is used when it is preferable to deliver the ultrasonic vibrations to the processed liquid by hand. Commonly, HACT-20 is connected to a Full-wave Barbell Horn. The ultrasonic output is activated by pressing the On/Off trigger on the transducer's body. Common applications include batch-mode ultrasonic degassing and mixing.

Air Fitting

In continuous duty operation, it is important to keep the transducer cool with flowing air. Use the air fitting to connect the cooling air source to the transducer. The cooling air must be filtered, dry and not warmer than 30 ^{0}C (86 ^{0}F). The air flow rate must be sufficient to ensure that the transducer's temperature remain below 40 ^{0}C

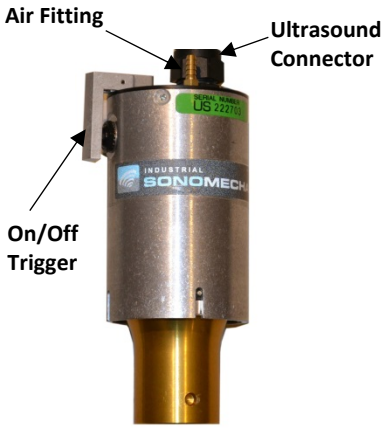

Figure 6 - 2. Hand-Held Air-Cooled Piezoelectric Transducer, HACT-20

CAUTION

Operating HACT-20 without cooling air may cause irreversible damage and is strictly prohibited.

Ultrasonic Horn

Liquids exposed to high-intensity ultrasound undergo ultrasonic cavitation, which produces violently and asymmetrically imploding bubbles and causes micro-jets that create extreme mechanical shear forces. These forces are responsible for the well-known ability of ultrasound to facilitate many physical and chemical processes. In order to produce sufficient cavitation intensity, ultrasonic transducers are equipped with high-gain acoustic horns, which amplify the vibration amplitudes generated by the transducers and deliver the ultrasonic energy to working liquids.

ISM offers many types of ultrasonic horns, which are described online under the following link:

http://sonomechanics.com/technology/ultrasonic_horn_designs_and_properties/

CAUTION

NEVER clamp the horn in a vise. The resulting scratches or gouges in the surface are stress risers which may result in cracks.

Attaching the Mounting Stud to the Horn

1. Inspect the stud for cracks or damaged threads. Replace the stud if it is cracked or otherwise damaged.

2. Remove any foreign matter from the threaded stud and the mating hole.

3. Thread the mounting stud into the input* end of the horn and lightly tighten using an Allen wrench in the socket head of the mounting stud.

*Always assemble the mounting stud that mates the transducer and the horn to the input end of the horn first.

NOTE

Do not apply any grease to the stud threads or the tapped hole. This may cause the stud to loosen. If the stud wanders within the joint, it can vibrate, resulting in excessive heat. In some cases, this can melt the tooling material.

CAUTION

Never leave a horn or booster assembly hand tight. Torque it to the proper specifications before proceeding. If the assembly is installed without being properly torqued down, the assembly may vibrate severely, damaging the mating surfaces and causing the generator to overload.

Attaching the Horn to the Transducer

1. Inspect all surfaces to be joined for stress cracks, chips, or gouges. Any of these irregularities will affect operation and could lead to further equipment damage.

2. Ensure that the mating surfaces of the two components are clean and smooth. These surfaces must make intimate contact for the mechanical energy to pass from one component to the next. Pitting or a buildup of old grease and dirt on a mating surface will interfere with the energy transfer and reduce the delivered power.

3. Make sure that the stud in the horn is tight. See the preceding mounting stud assembly instructions.

4. Remove any foreign matter from the threaded stud and mating hole.

5. Apply a thin layer of a high temperature, high pressure silicon grease to the surface that mates with the horn. The grease will allow both surfaces to intimately mate and become acoustically transparent which improves the energy transfer. We recommend Dow–Corning #4 (or #111 as an alternate). If you cannot use silicon–based grease in your facility, petroleum–based grease may be used. However, it is likely to leave carbonaceous deposits on the surface, and require more frequent joint maintenance. Failure to follow these

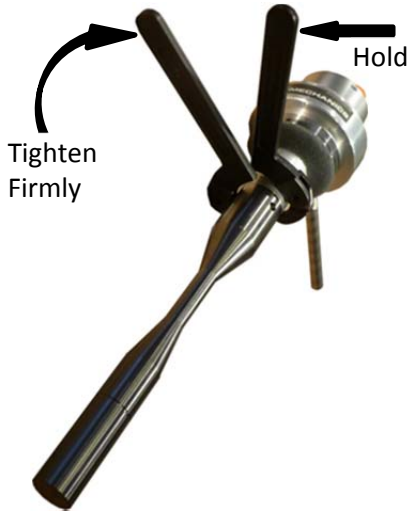

Figure 6 - 3. Transducer – FBH-Type Barbell Horn Assembly Procedure

instructions may result in the mating surfaces bonding and difficulty removing the horn from the transducer.

6. Thread the components together and tighten to the following torque specifications: 420 In-lb (35 Ft-lb or 47.5 N-m). Use spanner wrenches on components with spanner wrench holes (we recommend the following spanner wrenches: for components with diameters 31 - 75 mm - Armstrong Tools, part # 34-358; 19 – 30 mm - Armstrong Tools, part # 34-354) or an open end wrench on components with wrench flats. See Figure 6 - 3 for the correct procedure.

Detaching the Horn from the Transducer

On all transducers and horns with spanner wrench holes, use only the correct size spanner wrenches to provide sufficient torque to loosen a joint. See Figure 6 - 4.

Removing the Mounting Stud from the Horn

Only use an Allen wrench of the correct size in the socket head's stud to remove the stud from the horn.

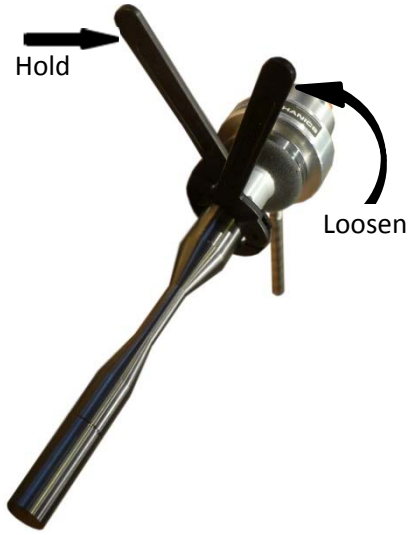

Figure 6 - 4. Transducer – FBH-Type Barbell Horn Disassembly Procedure

Testing the System

Step 1. Plug in the AC line cord to the correct AC power outlet.

Step 2. Connect the included cable with remote button switch to System Input Connector at the generator (**K** on Figure 4 – 1).

Step 3. Using the high-voltage coaxial cable, connect the ultrasound input connector at the transducer (Figure 6 – 1 and 6 – 2) to the ultrasound output connector at the generator (**M** on Figure 4 – 1). The horn should already be attached to the transducer.

Step 4. Insert the ultrasonic horn into water to a depth of between about 45 and about 65 mm.

Step 5. Push the AC Breaker/Switch **A** to the **ON** position.

Step 6. The **INFO LED** on the panel **B** should flash **RED** for 5 – 10 seconds. Then, it turns off (GRAY), and the LED above **ONLINE C** turns GREEN (if **ONLINE**).

Step 7. **ONLINE/OFFLINE** Tests

a. Press the **OFFLINE** key. The LED status indicator **C** turns to YELLOW.

b. Press the **TEST** key. The ultrasound should not activate.

c. Press the **ONLINE** key. The **LED** status indicator **C** will be GREEN.

d. Press and hold the **TEST** key. Ultrasound should activate. The display shows amplitude, power and operating frequency. The segmented power bar graph should also appear. See the sample screen display - Figure 6 - 6. If you are using a handheld transducer, you may feel a slight vibration or sensation in your hand. This is normal.

e. Release the **TEST** key. Ultrasound should deactivate.

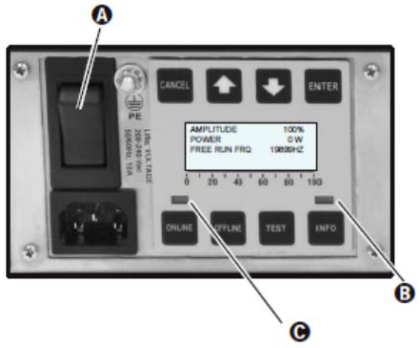

Figure 6 - 5. Control Panel at Startup

NOTE
Inserting the horn deeper than 65 mm into the liquid may cause the system to overload.

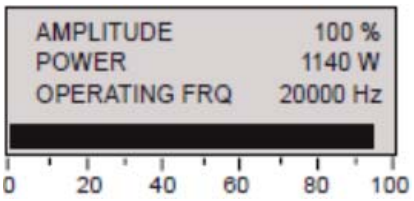

Figure 6 - 6. TEST Screen Display Sample

Running/Stopping the System

Running the System

Press the button on the remote button switch once. If you are using a handheld transducer, press the activation switch on its side. Ultrasound should activate. The display shows amplitude, power and operating frequency. The segmented power bar graph should also appear. See the sample screen display - Figure 6 - 6.

CAUTION
Any unusually loud noise from the trandsucer/horn indicates that they were improperly assembled

Stopping the System

Press the button on the remote button switch once again. If you are using a handheld transducer, release the activation switch on its side. Ultrasound will deactivate.

Alternatively, Press the **OFFLINE** key, and the ultrasound signal will deactivate.

Reactor Chamber

With the use of the reactor chamber (flow cell), the BSP-1200 ultrasonic processor can be configured for continuous liquid processing in a "flow-through" mode. When a large amount of material needs to be processed, this arrangement is preferable to the "batch" mode because it results in a much higher processing capacity, improved ultrasonic exposure uniformity and better temperature stability. During continuous ultrasonic processing, the use of the reactor chamber ensures that all working liquid is directed through the active cavitation zone(s) created by the incorporated Barbell horn (commonly, HBH-type), resulting in homogeneous ultrasonic exposure and high product quality. The reactor chamber commonly includes a water-cooling jacket to help maintain the temperature of the working liquid at a desired level. Alternatively, a separate heat exchanger may be utilized.

Figure 6 – 7 shows the reactor chamber assembled with a Half-wave Barbell Horn (HBH). Other types of Barbell horns may also be utilized with the same reactor chamber. The output diameter of the horn is commonly in the range of 30 - 35 mm, and the internal volume of the assembly is about 80 ml. The penetration of the horn into the chamber is arranged such that the non-vibrating mounting flange on the horn is "sandwiched" between the body of the reactor chamber and its lid through two O-rings, which ensures a reliable, pressure-resistant seal. The processed liquid is supplied through the "inlet" and collected through the "outlet" sanitary flange connections. Depending on the required process temperature, chilled water or ethylene glycol/water mixture may be supplied through the "cooling" hose barb connections at the reactor chamber's cooling jacket for temperature control.

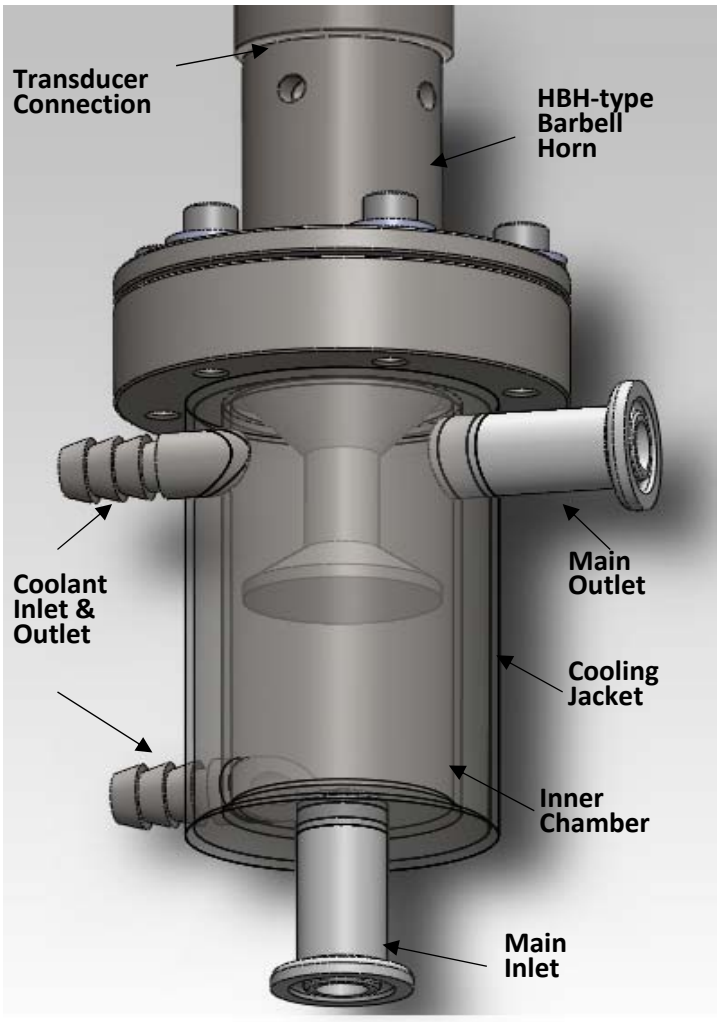

Figure 6 - 7. Reactor Chamber Assembled with a Half-wave Barbell Horn

Assembling the Reactor Chamber with a Barbell horn

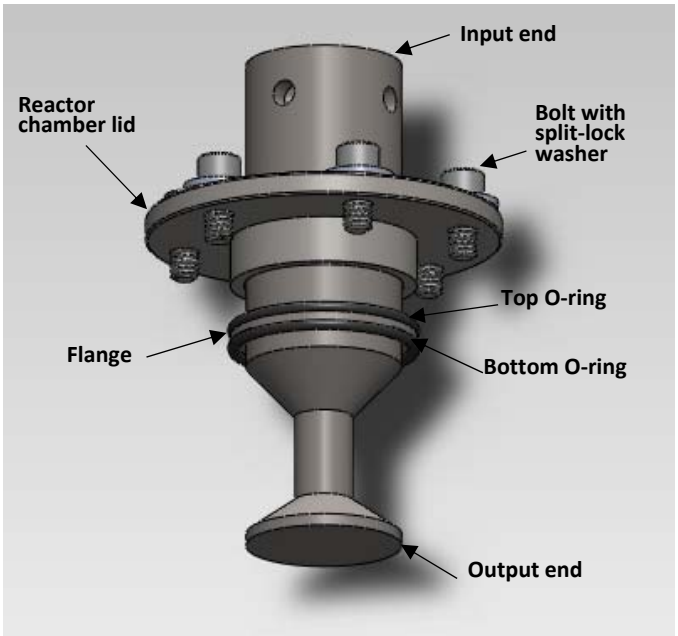

Figure 6 – 8. Step 1.

a) Insert six bolts with split-lock washers in the holes in the reactor chamber lid.

b) Place top O-ring over the horn such that it is in contact with the flange from the horn's input end.

c) Place reactor chamber lid with six bolts and washers over the horn from the horn's input end.

d) Place bottom O-ring over the horn such that it is in contact with the flange from the horn's output end.

Alternatively, place bottom O-ring into the receiving ring at the reactor chamber body (see Figure 6 – 10).

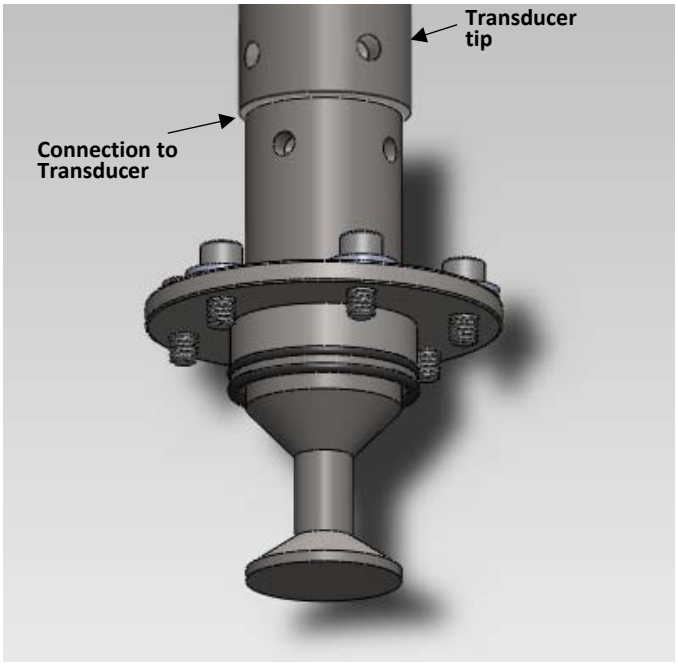

Figure 6 – 9. Step 2.

a) Assemble the transducer with the horn as described in Section 6, Figure 6 – 3.

b) Secure the transducer by its side arm in a support stand.

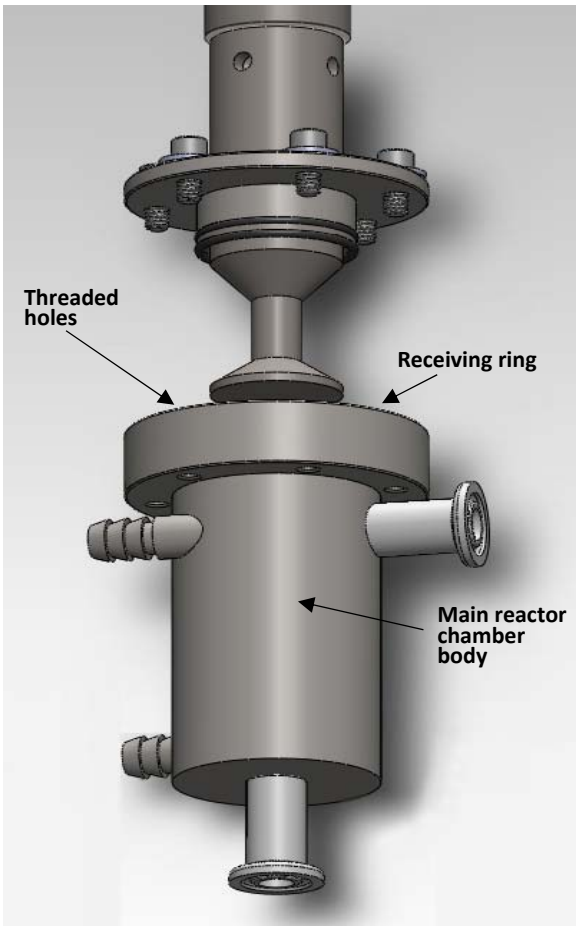

Figure 6 – 10. Step 3.

a) Align the main reactor chamber body such that when it is lifted the horn can enter its internal area.

b) Align the lid such that the bolts match up to the six threaded holes in the receiving ring.

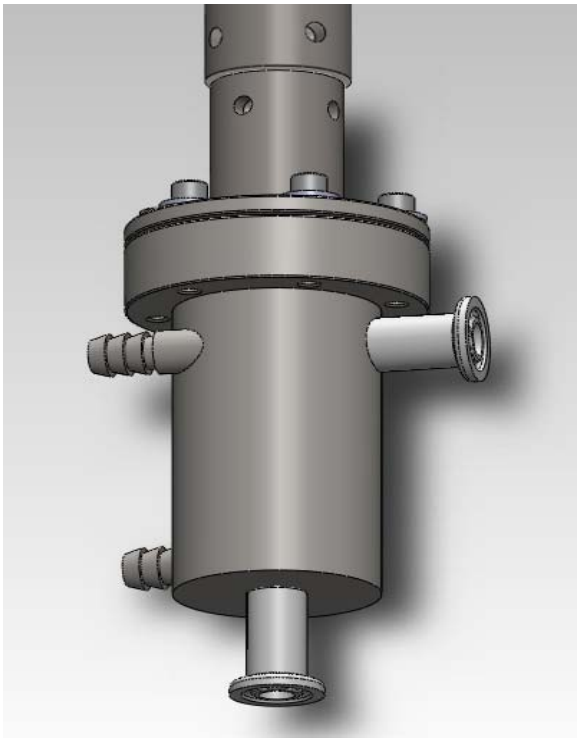

Figure 6 – 11. Step 4.

a) Lift the main reactor chamber body such that the bolts in the lid enter the threaded holes in the receiving ring.

b) Tighten the bolts evenly, maintaining same tension on all sides.

c) Secure the reactor chamber by its side arm in the support stand.

SECTION 7

Troubleshooting

NO ULTRASONIC OUTPUT **32**

TRANSDUCER 32
CABLES 32
GENERATOR 32

INFO STATUS LED: RED **32**

RED - FAULT CONDITION 32
OVERLOADS 32
OVERTEMPERATURE 33

No Ultrasonic Output

Transducer

Make sure that the high-voltage coaxial cable is connected to the transducer's ultrasound input connector (Figure 6 – 1) and the generator's ultrasound output connector (**M** on Figure 4 – 1). Also, make sure the horn and the transducer were properly assembled.

Cables

Make sure that both the high-voltage coaxial cable and the cable with remote button switch (or the handheld transducer's HD-15 input connector) are securely connected.

Place the generator **OFFLINE**, and check the coaxial cable for any signs of damage that may result in an open circuit preventing the cable from transmitting the generator-to-probe signal.

Generator

The generator will not produce an output signal when triggered if it is offline. Make sure that the **ONLINE** status LED is GREEN.

If the generator is **OFFLINE**, press the **ONLINE** key. See Figure 7 - 1.

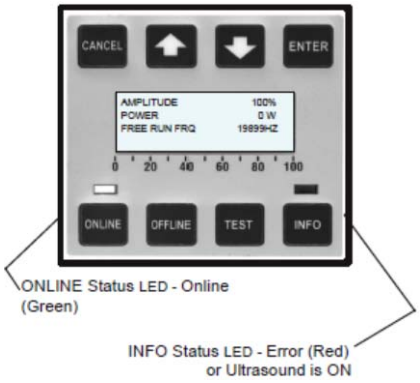

Figure 7 - 1. Status LEDs

INFO Status LED: RED

RED - Fault Condition

When the **INFO** status LED is RED (Figure 7 - 1) there is a fault condition.

Overloads

Overload - Frequency

There are two types of Overload-Frequency faults:

Frequency Failed, and *Frequency Lost.*

Other overloads are:

Overload - Peak, and **Overload - Average** (power above rating)

When an overload occurs, it will automatically reset when the next ultrasound activation signal begins.

If the condition persists, put the generator **OFFLINE** and:

1. Check the system: including cables, the transducer and the horn. Replace existing components with ones you know are reliable.

2. Frequently, the overload condition is caused by improper attachment of the horn to the transducer, for example when the attachment has loosened. Follow the procedure described in Section 6 to disassemble the horn from the transducer and the stud from the horn. Clean the mating surfaces and the stud. Follow the procedure described in Section 6 to reassemble the horn with the transducer. Make sure to tighten firmly.

NOTE

Be sure to press the ENTER key to clear the fault message and the INFO status LED.

The System Latch Reset Input will only clear the Output I/O faults.

If a fault occurs while using the TEST key, the TEST key will not function again until the ENTER key has first been pressed (to clear the fault message).

3. The overload condition may occur when the ultrasonic horn is inserted too deeply into the processed liquid during batch-mode operation. Make sure the horn is not inserted deeper than about 65 mm.
4. The overload condition may occur from excessive pressure in the reactor chamber during flow-through processing. Reduce the pressure to a value that does not cause the overload.
5. Press the **ONLINE** key to place the generator online, and see if the fault condition has been corrected.

Overtemperature

When the system overheats, there is an overtemperature condition that will cause the fault. When the system cools, the system automatically resets.

SECTION 8

Generator Specifications

DRAWINGS **35**
WEIGHT: **37**
AC POWER REQUIREMENT: **37**
OPERATING ENVIRONMENT **37**
STORAGE GUIDELINES **37**
REGULATORY AGENCY COMPLIANCE **37**
FCC 37
CE MARKING 37

Drawings

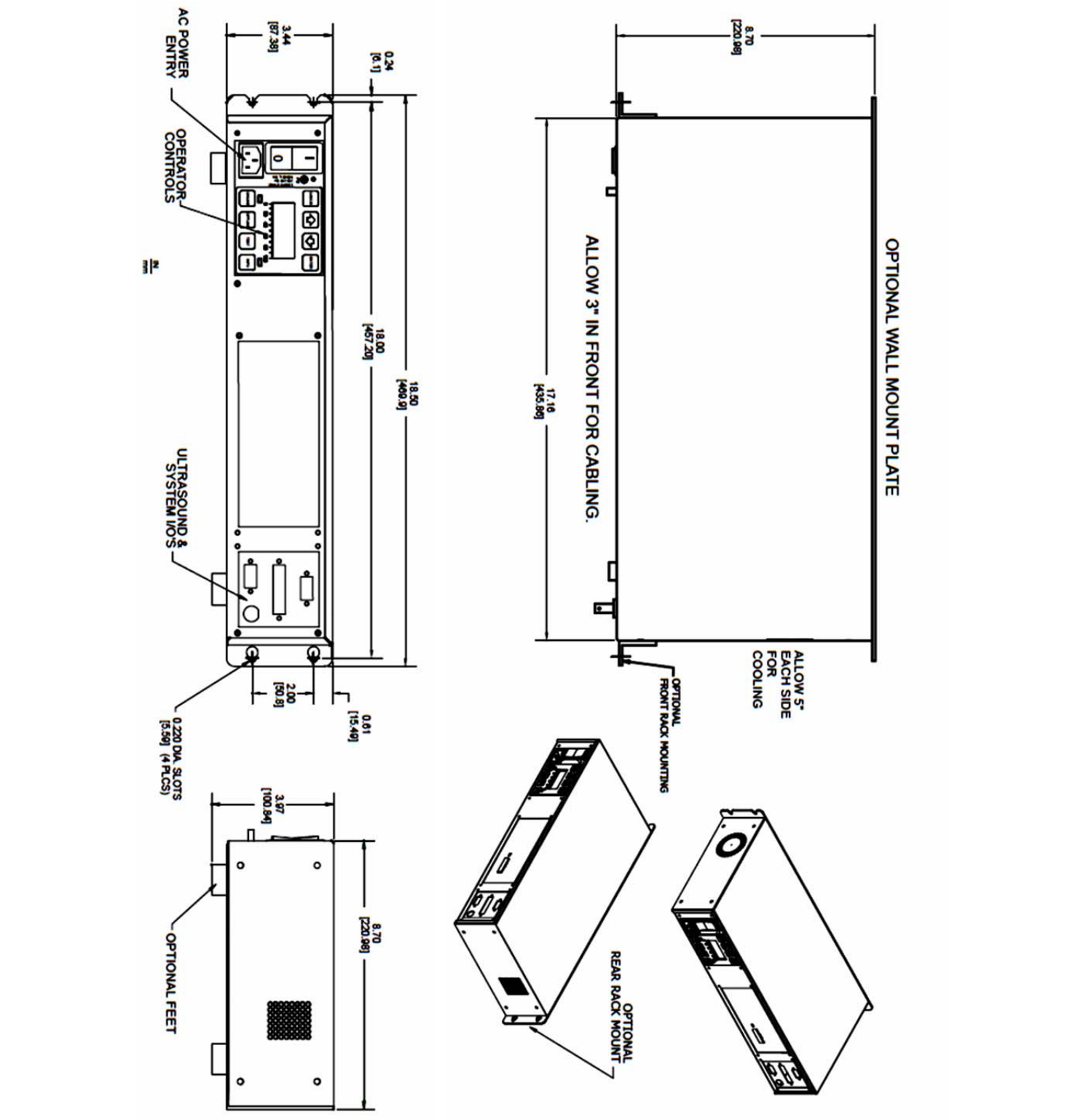

Figure 8 - 1. Low Profile Chassis Drawing

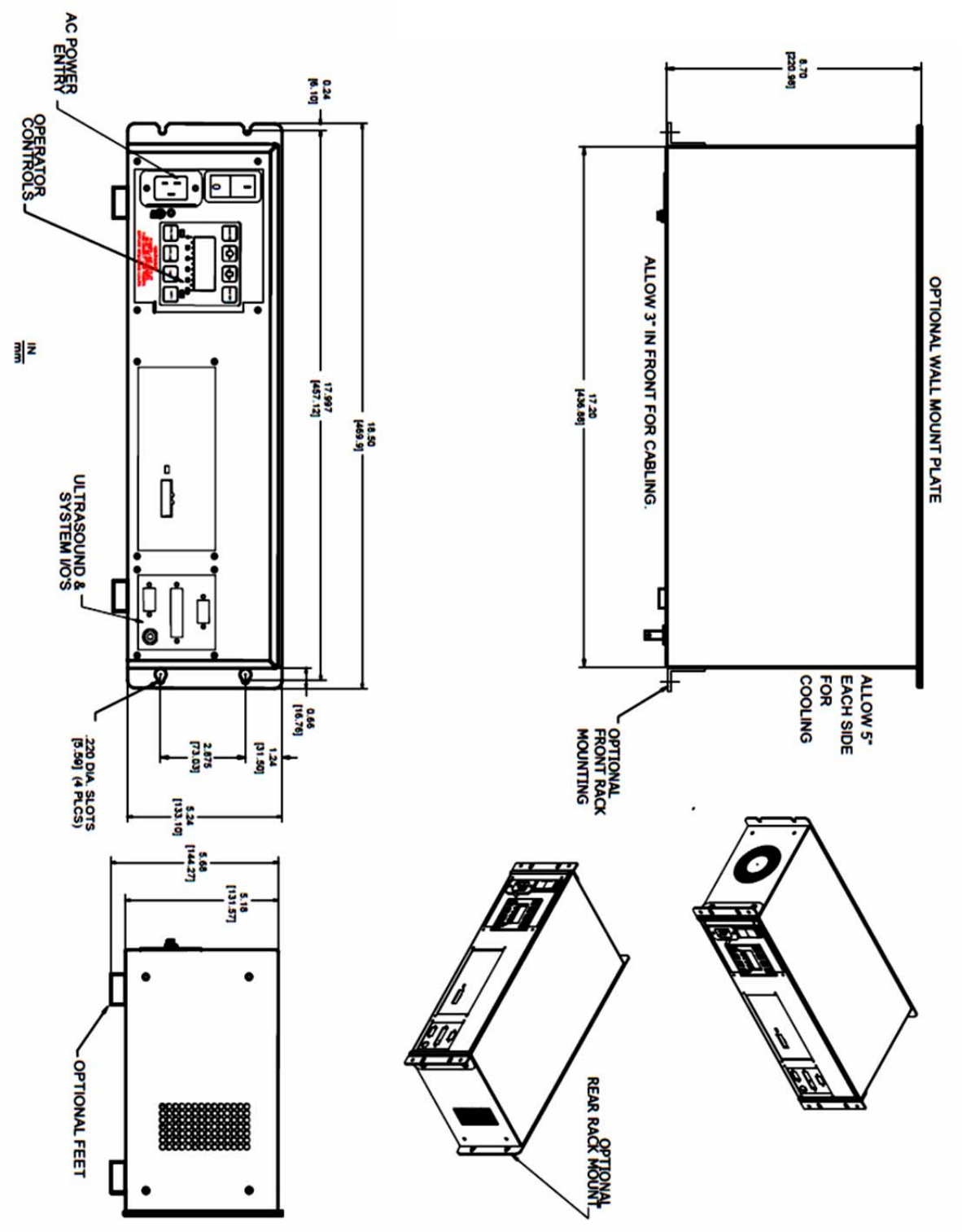

Figure 8 - 2. High Profile Chassis Drawing

Weight:

Low Profile Unit: 24 pounds (10.9 kg)
High Profile Unit : 30 pounds (13.6 kg)

Shipping: Add 5 pounds (2.3 kg) to unit weight for packing materials

AC Power Requirement:

Low Profile Unit: 200-240V 50/60 Hz @ 8 Amps
High Profile Unit : 100-120V 50/60 Hz @ 15 Amps

Operating Environment

Operate the generator within these guidelines:
Temperature: 40°F to 100°F (+5°C to +38°C)
Altitude: 15,000 ft (4572 m)
Air Particulates: Keep the equipment dry. Minimize exposure to moisture, dust, dirt, smoke and mold.
Humidity: 5% to 95% non-condensing @ +5°C to +30°C

Storage guidelines

(generator is not operating):
Temperature: - 4°F to 158°F (-20°C to +70°C)
Altitude: 40,000 ft (12,190 m)
Air Particulates: Keep the equipment dry. Minimize exposure to moisture, dust, dirt, smoke and mold.
Humidity: 5% to 95% non-condensing @ 0°C to +30°C

Regulatory Agency Compliance

FCC

The generator complies with Federal Communications Commission regulations.

CE Marking

This mark on your equipment certifies that it meets the requirements of the EU (European Union) concerning interference causing equipment regulations. CE stands for Conformité Europeéne (European Conformity). The equipment complies with the following CE requirements.
• The EMC Directive 2004/108/EC
for Heavy Industrial —
EN 61000-6-4: 2001
EN 55011: 2003
EN 61000-6-2: 2001
EN61000–4–2

EN61000–4–3
EN61000–4–4
EN61000–4–5
EN61000–4–6
EN61000–4–8
EN61000–4–11

- The Low Voltage Directive 2006/95/EC.
- The Machinery Directive 2006/42/EC.

EN 60204: 2006
Safety of Machinery - Electrical Equipment of Machines Part 1: General Requirements.